This is not the place for a critical estimate of Brown-Séquard's work, or an enumeration of his communications. The works by which he will be longest remembered are, perhaps, first, the investigations already referred to with regard to the sensory tracts in the spinal cord; secondly, his insistence on the complex nature of the cerebral functions, and the interaction of one part on another, leading to the phenomena of inhibition and reinforcement; thirdly, his studies on experimental epilepsy; fourthly, his observation that many of the organs of the body, such as the suprarenal capsules and other glands, both ductless and secretive, exercise an important influence on the nutrition of the body through the substances which they pour into the blood. These are all still living problems, and the work which he did on the last of them, though it has led to much adverse criticism, partly just, partly unjust, has borne and will bear practical fruit.

It is true that in collecting materials for the support of the conclusions which he reached he sometimes showed a lack of critical judgment which carried him too far, and impaired the weight of his authority in the eyes of many persons who were not in a position to know the real merit of his work, and to select the grain from the chaff. It is likewise true, however, that his researches gave birth to a splendid array of observations and generalizations, for which his name will be gratefully remembered by every sincere student of physiology.

His friend and co-worker Gley says of him, "Brown-Séquard was one of the greatest discoverers of facts that the world has ever seen."

1895. JAMES JACKSON PUTNAM.

HERMANN LUDWIG FERDINAND VON HELMHOLTZ.

HERMANN LUDWIG FERDINAND VON HELMHOLTZ, one of the most illustrious of European *savants* and one of the most distinguished of the Foreign Honorary Members of the American Academy of Arts and Sciences, was born at Potsdam, Prussia, on August 31, 1821.

Admitted at the age of seventeen to the Royal Military School at Berlin, he became Assistant Surgeon at La Charité Hospital, and later, as full Military Surgeon, was stationed at Potsdam. But after four years of service he relinquished the practice of medicine to enter upon congenial pursuits in extended and accurate mathematical and physiological researches, and in untiring investigations of various intricate questions in physics and optics.

One of the earliest of his published scientific papers, "On the Con-

servation of Force," gave him at once an acknowledged rank as *facile princeps* among the chief investigators in natural science. This was accompanied by other notable contributions; especially those on "The Nature of Putrefaction and of Fermentation," published in 1843; "On Animal Heat"; and on "The Consumption of Tissue during Muscular Action," in which was considered the question whether the living body gives off as much heat as is produced by the combustion and change of the food it takes in.

In 1849, Helmholtz became Professor of Physiology in the University of Königsberg, where he made notable investigations on "The Rapidity of Propagation of Nerve Excitation." By ingenious methods, of his own devising, for measuring extremely small differences of time, he was enabled to demonstrate that thought is not instantaneous, that it takes a definite period for us to become conscious of a fact, and that a certain measurable time elapses between the willing of a movement and the executing of it.

Helmholtz's original and intricate researches, begun thus early and including every department of physiology and of physics, are a record of amazing originality, acuteness, and industry, largely in new fields. They are especially remarkable for accuracy of observation, and quick discernment in the interpretation of the phenomena investigated. Nothing seemed so insignificant as to escape his notice, and little was so obscure as to defy his explanation.

Among the fruitful practical results of Helmholtz's untiring activities, we do not exaggerate in placing a superlative value upon his invention of the Opthalmoscope, — not only a most precious endowment of science, but as bestowing immeasurable benefits upon the whole human race.

We may well say, with Hasner: "The ophthalmoscope is not only the most valuable boon to ophthalmology, but is also one of the greatest creations of our century. What the telescope is to astronomy, the ophthalmoscope is to ophthalmology. The telescope owed its existence to an accident, but the ophthalmoscope is absolutely the mature offspring of theory, and is therefore a greater ornament than the former, not only to Helmholtz, its originator, but also to the age itself, which has not been here indebted to blind chance for great discoveries, but has known how to deduce them from exact and laborious scientific investigations."

Zehender, himself illustrious as an author and teacher, says of Helmholtz: "For more than two hundred years physiologists and mathematicians earnestly and with great sagacity sought for a solution

of the mode in which the eye instantly and involuntarily adapts itself for various distances, near and far. It was reserved for Helmholtz and his collaborator, Cramer, to solve this problem, by proving that an adaptive accommodation is effected by an increase of convexity of the crystalline lens, and principally of its anterior surface, through the agency of the ciliary muscle." The demonstration of these facts, by means of oblique illumination, was in this wise.

In a darkened room, a lamp flame, placed near the eye to be observed at an angle of about 30° from its visual axis, gives, while the eye looks at a distance, to an observer placed at about the same angle at the opposite side of the visual line, three reflected images of the flame: one erect, from the cornea; another, also erect, from the anterior capsule of the crystalline lens; and a third, an inverted and smaller image, from the posterior capsule of the crystalline. If now the observed eye, instead of looking at a distance, accommodates itself for a near object, say at twelve inches, the reflected image from the anterior surface of the lens appears lessened in size and approaches the corneal reflection, — a change which could result only from an increase of convexity of the anterior surface of the crystalline. The inverted image from the posterior capsule of the lens remains practically unchanged in size or position, proving that but slight, if any, change of curvature occurs at this posterior surface of the lens during accommodation for near objects.

Of all proof, we deem ocular evidence the most conclusive. Thanks to Professor von Helmholtz, we possess, in his supreme inquisitor, the opthalmoscope, an interpreter not only capable of revealing and explaining hitherto unknown physiological laws of normal vision, but which also affords clear and positive disclosures of previously unsuspected morbid processes, which, if unarrested, may imperil the most precious of our senses, and our chiefest means of instruction and of enjoyment. More than by any other faculty we live, and move, and learn, and enjoy by that of vision. To our eyes we owe almost everything we have, and are, and hope to become.

Were the revelations of the ophthalmoscope as to pathological and physiological conditions limited to such as affect the eye itself, they would still have an infinite value. But these disclosures have a still wider range, showing, through changes discoverable by its means in the retina and other internal structures of the eye, the advent of yet graver disease in other remote and most important parts of the body, — as, for instance, in the brain or the kidneys, — before the presence of any morbid tendency has been suspected.

Fortunately for science, Helmholtz was pre-eminently an observer and an interpreter; fortunately for science and for himself, he was destined to fill positions, one after another, not only of preferment, but of opportunity. When at an early age, in 1855, four years after his invention of the ophthalmoscope, he was appointed Professor of Anatomy and Physiology at Bonn University; then, three years later he became Professor of Physiology at Heidelberg University. Since 1871 he has been Professor of Physics at Berlin University, and in 1877 he became its Rector, becoming thus a veritable apostle of natural science.

On his election to membership in the French Academy he was hailed as "the foremost naturalist of his age, to whose glory nothing was wanting, but whose admission conferred fame upon the Academy." In 1873, the Copley Medal was awarded to him by the Royal Society of Great Britain.

In 1856, when thirty-five years old, Helmholtz published one of his works, modestly styled by himself a "Handbook of Physiological Optics," but which is a book of more than a thousand pages, — a stupendous monument of his patience, his alert and wise perception, his industry, and his accuracy in a field where not only conditions but functions came to be investigated in the light of new revelations, and where the observer must be a law unto himself.

It was this complete equipment of various knowledge, — in physiology, in physics, in biology, in mathematics, in optics, — joined to powers of quick and accurate perception and judgment, which so greatly enhanced the glory of Germany's and Europe's most illustrious and honored *savant*. It is hoped that the work of the later period of his career may be collected and published, to add yet further contributions to scientific knowledge.

In 1883 an hereditary title of nobility was conferred by the Emperor of Germany upon Helmholtz. In 1891, on his seventieth birthday, a jubilee ovation was tendered to him, where, in response to enthusiastic testimonials of admiration and affection from the German Emperor and other European sovereigns, from the President of the French Republic, from numerous learned societies and the great Universities, the Professor with great emotion referred to his disability of health in his earlier years of childhood, and spoke of his strong inclination, even from that period, for exact and experimental studies, which he had most zealously pursued.

In 1893, Baron von Helmholtz, accompanied by the Baroness, made a brief visit to this country, attending the Pan American

Medical Congress at Washington, and making a trip to the Chicago Exposition and the Western States. Coming afterwards to Boston and to Harvard College, they were greatly pleased with their visit. In paying a visit of respect to them, I remarked, "Professor, we know a hundred fold as much in opthalmology as before you gave us the ophthalmoscope." With a deprecating smile and gesture, he replied, "I was not even a Doctor of Medicine! I was only Professor of Physics at the University! but I set myself this problem, 'To illuminate if I could the interior of the eye,' — and I succeeded!"

Alas! but a few months have passed since the eclipse of that great light which had done so much for those who sit in darkness, for science, and for the world. As the creator of modern opthalmology, substituting by means of the opthalmoscope certainty for surmise, Helmholtz has bestowed an incalculable benefit upon mankind.

1895. H. W. WILLIAMS.

At the request of the late Dr. Williams the following account of the original work of Helmholtz was prepared to be added to the biographical notice.

The work of Helmholtz as an investigator seems to have begun while he was studying at Berlin in preparation for the profession of military surgeon, and his first scientific paper was his Promotionsschrift, "De Fabrica Systematis Nervosi Evertebratorum," published in 1842. Helmholtz's knowledge of mathematics, afterwards so profound, appears to have been at this time comparatively slight. His attention was chiefly devoted to physiology, though he was especially interested in physics for its own sake, as well as for the reason that accurate physiological measurements could be made only by persons who were able to devise and to use intelligently physical apparatus.

During most of the interval between 1842, when he became Militär Artz, and 1847, when, through the kind intercession of Alexander von Humboldt, he was honorably discharged from the army, Helmholtz was stationed in his native town of Potsdam, and there, besides carrying on his researches in physiology, some of the results * of which he published, he studied mathematics and physics, with the help of books borrowed from the library of the Gymnasium, to such

* "Ueber das Wesen der Fäulniss und Gährung," 1843. "Ueber den Stoffverbrauch bei der Muskelaction," 1845. "Die Physiologische Wärme," 1845. "Bericht über die Theorie der Physiologischen Wärmeerscheinungen für 1845." "Ueber die Wärmeentwickelung bei der Muskelaction," 1847.

good purpose that he was soon able to read easily the most abstruse treatises on these subjects, and to write his famous essay, "Ueber die Erhaltung der Kraft," in which the great doctrine of the conservation of energy was first forced upon the attention of physicists. The seven papers which Helmholtz published before he left the army had already (in 1848) given him a high reputation among physiologists, and after a year spent as teacher of anatomy at the Kunstakademie at Berlin, he was called to a Professorship of Physiology and Pathological Anatomy at Königsberg. During the six years which he spent here Helmholtz published about twenty papers, mostly of great importance, and of these almost all, except those on the velocity of propagation of nerve excitation, and on the duration of induced electric currents, had to do with physical or with physiological optics.

These twenty papers, however, do not represent the whole of the work which Helmholtz did at Königsberg beyond his professional duties, for he must have written here the greater part of his "Handbuch der Physiologischen Optik," the first edition of which appeared in 1856. It was by this time clear that Helmholtz had become one of the first of living physicists. Almost every one of his publications, whatever its title, showed his mastery in some branch of physics, and made some contribution to the world's knowledge of the subject.

From Königsberg, Helmholtz went to Bonn, and thence, in 1858, to Heidelberg, where he remained as Professor of Physiology until 1871. While at Bonn and Heidelberg he published forty-three considerable papers, besides his "Lehre von den Tonempfindungen," which appeared in 1862, and which he says in his Preface is fruit of work stretching over eight years,* though of the fourteen publications which he wrote in the six years after he left Königsberg at least five have to do with matter foreign to acoustics and to tone-sensations. One of these was an epoch making paper in mathematical physics, in which it was shown that vortex rings and vortex filaments in perfect fluids under the action of conservative forces are indestructible, and that such rings and filaments apparently attract or repel one another according to the relative signs of their vorticities.

One may get some conception of the catholicity of Helmholtz's tastes and of the extent of his knowledge by reading a list of the subjects of the papers which he wrote at Heidelberg on Physiology, Physical and Physiological Optics, Physical and Physiological Acoustics, the

* "Indem ich die Früchte achtjähriger Arbeit der Oeffentlichkeit übergebe," etc.

Theory of Perception of Geometrical Truth, the Doctrine of Energy, Hydrodynamics, and Electrodynamics. Towards the end of his stay in Heidelberg, his attention was more and more turned in the direction of physics and away from physiology. He had certainly become the greatest living German physicist, and when Magnus died, in 1871, it was on all sides agreed that he should be called to take the Directorship of the Physical Laboratory of the University at Berlin, and natural that he should accept the position. From this time on by far the larger part of his own experimental work was in the domain of physics, though he suggested and helped on to success the researches in physiology of other experimenters, and when it became necessary to review the whole literature of physiological optics on the occasion of the preparation of a new edition of his Handbuch, he spent much time and energy in studying and in drawing conclusions from the work of others in this field.

Some of the most important of the later contributions of Helmholtz to mathematical and experimental physics are contained in his papers on, —

1. Possible Discontinuities in the Motion of a Frictionless Fluid.
2. The Theory of the Motion of Viscous Fluids.
3. The Thermodynamics of Chemical Processes.
4. The Theoretical and Practical Limits to the Resolving Powers of Microscopes.
5. Electrolytical Processes.
6. The Fundamental Laws of Electrodynamics.
7. Electrical Oscillations and the Nature of Electricity.

In 1888 Helmholtz resigned his place at the head of the Berlin Laboratory in order to take charge of the newly established Reichs-Anstalt at Charlottenburg, and the last years of his life were chiefly spent in organizing the work of this institution.

GASTON, MARQUIS DE SAPORTA.

The Marquis de Saporta was born on July 28th, 1823, and died at the age of seventy-one years on January 26th of the present year, at his residence in Aix-en-Provence.

Since the appearance of his first paper on the Fossil Plants of Provence in 1860, he has been a prominent palæobotanist, and yields to few cultivators of that science in the number, variety, and importance of his memoirs and larger works. His greatest and most important work is that on the Mesozoic Flora of France, to which he added